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Formation of the Mont Dieu IIE non-magmatic iron meteorite. N. Van Roosbroek[1], V. Debaille[1], S. Goderis[2], J. W. Valley[3], M. J. Spicuzza[3] and Ph. Claeys[2], [1]Laboratoire G-Time, Université Libre de Bruxelles, B-1050 Brussels, Belgium,[2] Earth System Sciences, Vrije Universiteit Brussel, B-1050 Brussels, Belgium, [3]Dept. of Geoscience, Univ. of Wisconsin-Madison, Madison, WI, 53706, USA.

Introduction:

Recently, the Mont Dieu meteorite was confirmed as a fine octahedrite IIE iron meteorite [1, 2, 3]. The original fragments in the collection of the *Musée National d'Histoire Naturelle* in Paris show rust damage. The much better preserved ~450 kg fragment of the IIE non-magmatic iron (NMI) Mont Dieu II meteorite hosted at the Royal Belgian Institute of Natural Sciences, in Brussels, was studied. The metal phase shows a clear widmanstätten texture, composed essentially of kamacite, with fine lines of Ni-rich taenite, and locally troilite associated with schreibersite. The study focuses on the abundant large, angular, brownish silicate inclusions present in Mont Dieu II. These were studied under SEM/EDX, major and trace elements were determined by ICP-OES & ICP-MS, and oxygen isotopes were measured.

Silicate inclusions:

The silicate inclusions are characterized by coarse-grained granular texture, crossed by metal veins ranging from abundant fine veinlets to a few coarse veins of 100-250 µm wide. Round structures (~ 1 mm in diameter) composed of ferromagnesian minerals are spread throughout the silicate inclusions and are interpreted as relict chondrules. The majority of these chondrules have a recrystallized appearance but three well preserved barred olivine chondrules, a feature so far only present in Netschaëvo IIE [4], have been observed. The mineralogy is of chondritic nature. It contains low Ca-pyroxene, olivine, plagioclase, glass, Fe-Ni, troilite, chromite and phophates. Glass is only found within the chondrules and contains up to 4.7 wt% FeO. The composition of this glass can best be compared to chondrule glass.
The Fa and Fs molar contents are defined for three different regions in the silicate inclusions; the well preserved chondrules, the recrystallized chondrules and the matrix. For both chondrule groups, these values fall within the H-range (Fs = 14.9 ± 6.3; Fa = 17.4 ± 5.3 for the original chondrules. Fs = 15.0 ± 2.5; Fa = 16.4 ± 2.7 for the recrystallized chondrules). For the matrix the Fa and Fs molar contents are 14.9 ± 1.5 and 12.9 ± 0.6 respectively, more reduced compared to H-chondrites. Olivine and low-Ca pyroxene show a wide compositional range (2σ) which is decreasing from original chondrules to recrystallized chondrules to matrix.

The major element composition of the silicate phase of Mont Dieu II can best be compared to enstatite and ordinary chondrites. Because barred olivine chondrules do not occur in enstatite chondrites, an enstatite chondrite affinity is excluded. Within the ordinary chondrites, the composition of Mont Dieu II can best be compared to H-chondrites.

The oxygen isotope analyses carried out on Mont Dieu II yield a mean $\Delta^{17}O$ of 0.714±0.024 ‰. In terms of its oxygen signature, Mont Dieu II falls within the range defined for H 3-6 chondrites [5; 6].

The silicate inclusions show similarities with H6 chondrites, where small chondrules have disappeared and the groundmass has coarsened. It is likely that the silicate minerals underwent appreciable metamorphic recrystallization but that melting was very limited. Metal, troilite and phosphates minerals have an irregular and elongated shape, indicating that these minerals were once molten. From these observations, it is clear that Mont Dieu II has been heated.

Precursor material:

Several lines of evidence let us believe that Mont Dieu II originated as an H-chondrite; the preserved chondrules, the chondritic mineralogy, its major element composition and its oxygen isotopic composition. Three other important features indicate that the precursor material could have been an unequilibrated H3 chondrite; (1) The occurrence of chondrule glass in some chondrules, (2) The wide compositional range of the minerals in those chondrules and (3) The oxygen isotopic composition that is situated in the H3 range.

Formation:

An impact formation model is proposed. An H-chondrite parent body was impacted by an Fe-Ni impactor that created a metal-magma pool on the surface of the H-chondrite parent body. The material of the impactor is mixed with the silicate material when sinking towards the bottom of the magma pool. A certain amount of the impactor sinks to the magma pool. The upper part of the magma pool consists of a silicate-metal mixing region. In this environment, Mont Dieu II was formed. A position near the edge and at a shallow depth of the magma pool is favored for Mont Dieu II, because fast cooling is necessary to preserve the chondrules and glass. No strong evidence for shock was observed in the silicate phase, meaning that Mont Dieu II did not form at the surface of the parent body. An H3-chondrite affinity for Mont Dieu II is consistent with the onion shell model, where the least metamorphosed regions are situated at the surface of the H-chondrite body, where the impact took place.

Classification:

To position Mont Dieu II within the IIE group several classification criteria have been evaluated. The occurrence of chondrules in the silicate phase of Mont Dieu II, its major element composition and its chondritic mineralogy place Mont Dieu II on the same level as Netschaëvo. The preservation of chondrule glass and its oxygen isotopic composition favor a more primitive nature for Mont Dieu II and therefore we propose that Mont Dieu makes up a new, the most primitive subgroup, within the IIE classification.

References:

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